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Section ________

PHYSICS 315 – COMBAT AVIATION PHYSICS

Spring 2002

Application Exercise 3

Radar Diffraction

Due: *Beginning of class*, lesson 24

100 points

To receive full credit you must show all work and communicate efficiently using proper grammar.

AUTHORIZED RESOURCES: *any published or unpublished sources and any individuals*.

Document appropriately! ____

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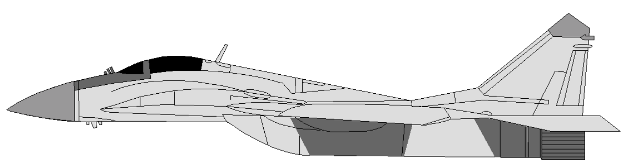
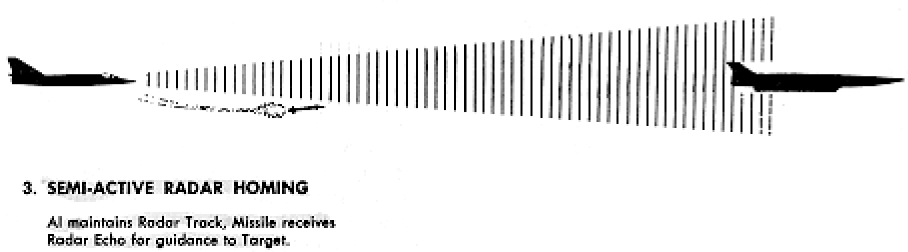


Mig - 29

Purpose: After an extremely dangerous and politically sensitive ESM mission into Iraq, two of our operatives have commandeered a new Continuous Wave (CW) radar that will be used on Iraq's new version of the Mig-29. The purpose of this radar is to illuminate targets with a beam of RF energy for an air-to-air missile that will be carried on the Mig-29. This type of weapon guidance is called semi-active guidance and works by the missile homing in on the reflected RF energy from the illuminated target.

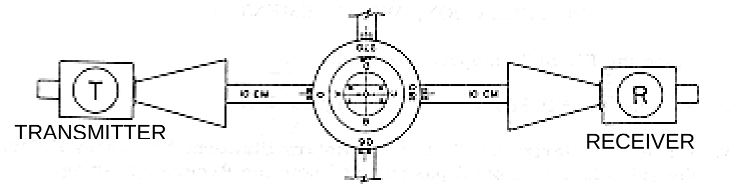


Your mission is to find out for the Defense Intelligence Agency the horizontal radiation pattern the transmitter produces, the 3dB beam width (θ_{3dB}), and the radar's operating frequency.

Equipment: CW illuminator transmitter with feed horn antenna, receiver with same feed horn antenna, Rotary platform with attachment arms, polar plotting paper and 12 inch ruler.

Procedures:

1. Arrange the transmitter and receiver directly facing each other and 20 cm apart. (See Figure below)



2. Set the gain control on the receiver to 3. Ensure the transmitter is plugged into an outlet and turn it on by rotating the repeller tuning knob in a clockwise direction. The red pilot lamp will light, indicating that power is "ON." Wait at least two minutes to permit the transmitter to warm up and stabilize.

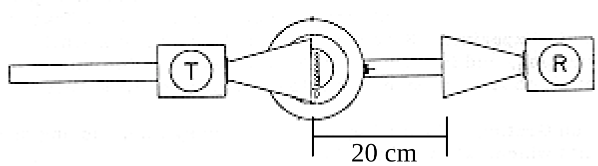
3. Very slowly adjust the repeller tuning knob (located on the top of the transmitter) to obtain maximum power on the receiver's meter. Do this very carefully and note the Repeller tuning knob setting for each peak reading on the receiver meter. After each peak has been explored, return the repeller tuning knob to the setting which gave the highest reading.

<u>WARNING: The transmitter's Klystron (the black dome on the transmitter) can become very hot during use. Do not touch the Klystron when the transmitter is on.</u>

<u>CAUTION: When seeking a peak reading by moving the transmitter, receiver or rotary platform, all changes in the position of these components must be made very slowly.</u>

NOTE: During all experiments, avoid placing your hands or any other object within the field while making measurements. Failure to do so will cause inaccurate meter readings.

4. Turn the gain control on the receiver to 0. Place the transmitter on the rotary platform arm at the 180 degree position so the end of the horn antenna is over the center of the rotary platform. Place the receiver on another platform arm located at the 0-degree position with the end of its horn antenna approximately 20 cm from the end of the transmitter's horn antenna. See Figure below.



5. In the above configuration, vary the gain of the receiver until the meter is reading nearly 100% relative intensity. **<u>CAUTION: Do not go above 100% on the receiver meters</u>**. Record this reading on the polar chart with a dot at the proper location (0 degrees).

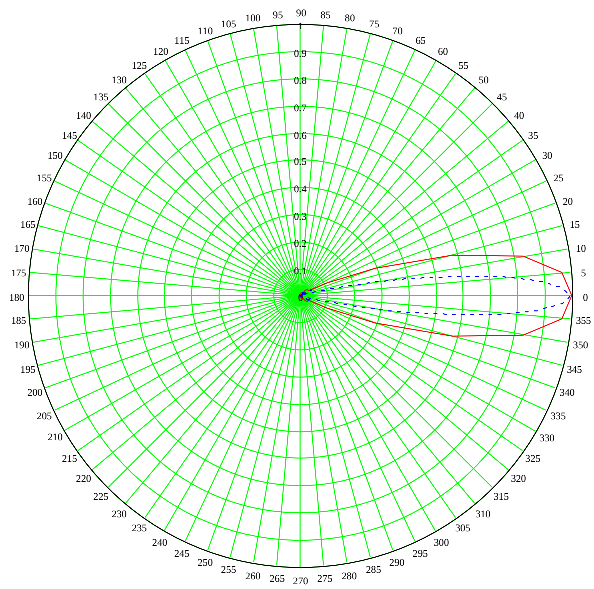
6. From this 0-degree position move the receiver clockwise or counter-clockwise 5 degrees. Record the receiver's reading of relative intensity on the polar chart with a dot. Perform this procedure 17 times until the receiver is at the 90-degree position. You should have a total of 18 dots on your polar chart.

7. Copy the dot locations to the opposite side of where you plotted the original dots using the 0-degree line as the line of symmetry.

8. Connect the dots with straight lines on your plots using the ruler to produce the transmitter's radiation pattern.

9. Find the two points on your plot where the beam intensity is at the 3dB level (50%) and mark these locations with a "X." For each X, draw a dashed line from the center of the plot through the X and to the outer edge of the polar chart. Write the degree that these lines intercept on the line.

10. Due to the receiver's antenna also having a radiation pattern similar in shape to the one you found, the intensity for each angle in the radiation pattern from above is stronger then what the actual intensity is directly at angle you made a measurement at. This happens due to the receiver adding up all the EM energy in its beam width and not just the energy at one point. The polar plot below shows what your original plot might look like (the solid line) and what the actual plot should be (the dashed line).



The effect on θ_{3dB} is that the radiation pattern you plotted doubles θ_{3dB} from the actual θ_{3dB}. To compensate for this, mark on your plot the true points that define θ_{3dB} and label them with a "0".

11. Measure the horizontal width of the feed horn antenna and record this below the radiation pattern.

CW Illuminator Lab Analysis

(20) 1. What is the actual θ_{3dB} for the CW illuminator's transmitted beam? Please attach your radiation pattern plot.

(40) 2. Using θ_{3dB} from above and the horizontal width of the horn antenna, what is the approximate wavelength of the transmitter?

(40) 3. Using the above wavelength, what is the transmitter's approximate carrier frequency?

(40) 4. Due to the receiver having the same θ_{3dB} as the transmitter, it may not be apparent from the radiation pattern you produced that there are side lobes and nodes for this radiation pattern. Assuming the transmitter produced a simple diffraction pattern, what is the angular location of the first node? (HINT: Think back to Phys 215's single slit diffraction pattern equation)

(20) 5. Before, in class, we stated that a CW radar needs two antennae – one for transmission and another for reception. In the case of semi-active guidance, where are the two antennae located?